19p.

N64-20581 6

CAT. 21 CODE-1

NASA TECHNICAL MEMORANDUM

NASA TM X-53009

February 21, 1964

NASA TM X-53009

DIRECTIONAL WIND COMPONENT FREQUENCY ENVELEOPES, CAPE KENNEDY, FLORIDA, ATLANTIC MISSILE RANGE

by O. E. SMITH AND G. E. DANIELS

Aeroballistics Laboratory

NASA

George C. Marshall Space Flight Center, Huntsville, Alabama

OTS PRICE

XEROX $ $1.60 ph.

NASA - GEORGE C. MARSHALL SPACE FLIGHT CENTER

TECHNICAL MEMORANDUM X-53009

DIRECTIONAL WIND COMPONENT FREQUENCY ENVELOPES CAPE KENNEDY, FLORIDA, ATLANTIC MISSILE RANGE

By

Orvel E. Smith and Glenn E. Daniels

ABSTRACT

20581

Directional Wind Component Frequency Envelopes for Cape Kennedy, Florida, based on the "windiest monthly period" concept, are presented in this report for use in structural and control studies in the design of aerospace vehicles.

AUTHOR

NASA - GEORGE C. MARSHALL SPACE FLIGHT CENTER

TECHNICAL MEMORANDUM X-53009

February 21, 1964

DIRECTIONAL WIND COMPONENT FREQUENCY ENVELOPES CAPE KENNEDY, FLORIDA, ATLANTIC MISSILE RANGE

By

Orvel E. Smith and Glenn E. Daniels

TERRESTRIAL ENVIRONMENT GROUP
AERO-ASTROPHYSICS OFFICE
AERO-ASTRODYNAMICS LABORATORY

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

NASA - GEORGE C. MARSHALL SPACE FLIGHT CENTER

TECHNICAL MEMORANDUM X-53009

DIRECTIONAL WIND COMPONENT FREQUENCY ENVELOPES CAPE KENNEDY, FLORIDA, ATLANTIC MISSILE RANGE

By

Orvel E. Smith and Glenn E. Daniels

SUMMARY

Directional Wind Component Frequency Envelopes for Cape Kennedy, Florida, based on the "windiest monthly period" concept, are presented in this report for use in structural and control studies in the design of aerospace vehicles.

20581

I. INTRODUCTION

A

This report is a first attempt to present data for use in developing idealized wind component profiles analogous to the synthetic wind speed profiles which are presently being used for aerospace vehicle design criteria by most organizations. Due to the predominance of strong westerly winds in winter and relatively light but persistent easterly winds in summer in the troposphere over Cape Kennedy, some potential gain in structural and control system design requirements may be realized by using directionalized synthetic wind profiles instead of the present nondirectional wind speed synthetic profiles.* The extent of a design gain depends upon the flight azimuth restrictions imposed on the vehicle and the response characteristics of a given vehicle configuration.

Author

* See MTP-AERO-63-8, "Natural Environment (Climatic) Criteria Guidelines for use in MSFC Launch Vehicle Development, 1963 Revision," January 28, 1963.

II. DESCRIPTION OF BASIC DATA

The basic data used to prepare these graphs and tables consist of six years of rawinsonde wind data (1956-1961) which were serially completed (missing data inserted by interpolation, extrapolation, or use of data from nearby stations) by professional meteorologists of the National Weather Records Center. Wind speed and direction are given for each kilometer of altitude from the surface to 27 kilometers. Therefore, the statistical values quoted are with reference to this basic set of wind profile measurements made twice daily for a period of six years. The data do not include the turbulence and high frequency component of the vertical wind profile, and therefore represent the "steady state" part of the true wind profile characteristics.

III. PREPARATION OF GRAPHS AND TABLES

The wind speeds and directions were resolved to components with respect to a rotating orthogonal coordinate system which was rotated in increments of 15 degrees. By convention, at Marshall Space Flight Center the positive longitudinal and negative longitudinal wind components are considered as tail wind and head wind components, respectively. Similarly, the positive and negative lateral wind components are right-cross and left-cross wind components, respectively. Since the algebraic sign of the wind components with respect to the orthogonal planes are retained, unbounded frequency distributions are obtained. Cumulative percentage frequencies are computed. Then, the numerical values of the longitudinal and lateral wind components corresponding to the cumulative percentage frequencies of 30, 50, 90, 95, and 99 and the complements of these frequencies (i.e., 1, 5, 10, 50, 70%) are calculated. These operations produce values of the tail and right-cross wind components at stated cumulative percentage frequencies and the values of the head and left-cross wind components are obtained from the complements of the stated cumulative percentage frequencies. The values of the wind components (in m/sec) corresponding to the cumulative percentage frequencies are called percentiles. The relation between percentiles and probability follows immediately: Given that the 90th percentile of the wind component is say, 68 m/sec means that there is a probability of 0.90 that this value of the wind component will not be exceeded and there is probability of 0.10 that it will be exceeded for the set of data from which the percentile was computed. Stated in another way: There is a 90% chance that the given wind component will not be exceeded or there is a 10% chance that it will be exceeded. If one considers the 10^{th} and 90^{th} percentile for the wind components, it is clear that 80% of the wind components occur within the 10-90 percentile range.

The percentiles were computed for the wind components at one kilometer altitude intervals from the surface to 27 kilometers for each monthly period. Envelopes for the monthly percentiles were constructed for all altitude levels. From these monthly percentile envelopes, envelopes were constructed which enclosed all monthly percentile envelopes and idealized by linear segments for the 5 to 6, 10 to 14, and 18 to 20 kilometers altitude intervals. These idealized wind component envelopes for the several percentiles are presented for the discrete altitudes 5 to 6 kilometers, 10 to 14 kilometers, and 18 to 20 kilometers in Figures 1, 2, and 3 and Tables I, II, and III. The 99 percentile envelope for each of the three altitude intervals is illustrated in Figure 4. Similarly, the 95 percentile envelope is shown in Figure 5.

IV. WINDIEST MONTHLY REFERENCE PERIOD CONCEPT

As used in this document, the wind data for the various percentiles refer to the "windiest monthly period." This means that the wind speed values were computed for the given cumulative percentage frequencies or probability levels for each of the twelve monthly periods represented by the six years of data, i.e., six Januaries, six Februaries, etc. The maximum wind speed value of all the twelve monthly periods was selected for each percentile, as noted in Section III. This produced a wind speed value for each 15 degrees of azimuth, for a given percentile, not exceeded by the observations for the "windiest monthly period." Obviously, the wind speed values for a given percentile envelope may come from different months, depending on the strength and persistence of the wind speeds for the various azimuths.

The philosophy is to produce a set of statistics such that the maximum wind component value for a given percentile may be readily determined for a given azimuth, based on a windiest monthly reference period concept. It is therefore evident that, in general, only one monthly period will control the selected component wind speed value for a given azimuth and percentile. For the other eleven monthly periods, a smaller value of the wind component will exist. However, where there is concern for insuring that the largest wind component value for a given percentile during a monthly period is determined, this type of presentation insures selection with a minimum effort.

V. USE OF DATA

Interpretation of the data from this report is as follows. Wind component envelopes for cumulative percentage frequencies of 30%, 50%, 75%, 90%, 95%, and 99% are provided for three altitude regions: 5 to 6 km (Figure 1 and Table I), 10 to 14 km (Figure 2 and Table II) and 18 to 20 km (Figure 3 and Table III). The graphs and tables may be used to answer the following type question: For a given flight azimuth - say to 105 degrees east of north at an altitude between 10 and 14 km - what is the head, tail, right-cross or left-cross wind component which will not be exceeded 95 percent of the time for the windiest monthly period? For this case there is a 95 percent chance that a head wind will not exceed 21 m/sec; for the right-cross it is 50 m/sec; for the tail wind it is 73 m/sec; and for the left-cross wind it is 25 m/sec (see Figure 2). Similar questions can be answered for any given flight azimuth with respect to the wind component magnitudes in various altitude regions. Similarly, with respect to this graph, information can be obtained for those vehicles which are critical to quartering winds - that is, for a flight azimuth of 105 degrees, at 10 to 14 km altitude region, it might be determined that a wind component acting from 240 degrees and 330 degrees might be the most critical. For this case, there is a 95 percent chance that the right quartering wind component will not exceed 73 m/sec and the left quartering wind component 50 m/sec.

If information is required for altitudes between those given, linear interpolation may be used as follows to obtain a first approximation:

a. To find the head wind value at 8 km associated with the 95 percent value for a 105 degree flight azimuth, the 95 percent value for 5 to 6 km is 9 m/sec (see Figure 1) and for 10 to 14 km (10 km) is 21 m/sec (see Figure 2); therefore, by interpolation

$$\left(\frac{8 - 6}{10 - 6}\right) (21 - 9) + 9 = 6 + 9 = 15 \text{ m/sec.}$$

Note that the bottom of the 10 to 14 km altitude wind zone is used, since this is the maximum wind zone; and all velocities are assumed the same in this zone, for the purpose of this calculation, at given probability levels.

b. To find a wind value between the 10 to 14 km and 18 to 20 km region, interpolation will be made between 14 km and 18 km.

c. Interpolation should be performed only within one plane, that is, with respect to altitude and wind component. Interpolations between altitude and wind components along different azimuths are not valid.

It should be pointed out that the graphical scales of wind speed vary between the graphs. This was necessary to present the data in the most useful form. Figures 4 and 5 show the 99% and 95% percentile wind speeds on the same scale so that the relative wind speeds for the various altitude levels can be compared.

VI. CONCLUDING REMARKS

These data should be employed in vehicle studies with caution. The Aero-Astrophysics Office of the Aero-Astrodynamics Laboratory, should be contacted before any final decisions are made on design problems using this information to insure proper interpretations of these data.

The data presented in this paper are essentially an extension and updating of similar data presented in a number of internal MSFC office memoranda* on flight azimuth restricted wind component values. The differences in the numerical values that appear in this report from those in the office memoranda are due primarily to use of the recently completed six-year serially complete data dect. In addition, the data contained herein are "internally consistent." In other words, the overall statistical analysis for all flight azimuths was taken into consideration rather than one specific azimuth. The wind speed data contained in this document seldom exceeded a difference of 4 m/sec from previously published data.

---

* For example the following MSFC Internal Office Memoranda are cited:

M-AERO-G-23-61, "Annual Component Wind Speed Envelopes for 100 Degrees Flight Azimuth at Cape Canaveral, Florida," April 4, 19641.

M-AERO-G-26-61, "Annual Component Wind Speed Envelopes (1 to 80 km Altitude) for 100° Flight Azimuth at Cape Canaveral, Florida," April 4, 19641.

M-AERO-G-3-62, "Inflight Wind Design Criteria for the OAO and EGO Launch Vehicle," March 21, 1962.

M-AERO-G-4-62, "Amendment to Atmospheric Design Criteria for the 3-Stage Atlas/Centaur/Surveyor Bus Vehicle for Advent Missions," April 9, 1962.

M-AERO-G-6-62, "Inflight Wind Design Criteria for Project Fire Vehicle (Flight Reentry Research Proj & High)," April 20, 1962.

M-AERO-G-19-62, "Frequency of Head and Tailwinds for Firing Azimuth of 100 Degrees, and Persistence of Wind in the 10-14 km Altitude Layer for Cape Canaveral, Florida," July 31, 1962.

M-AERO-G-20-62, "Idealized Monthly 84, 90, 95, and 99% Component Wind Profile Graphs, Cape Canaveral, 95° - 115° Flight Azimuth," August 3, 1962.

M-AERO-G-34-62, "Idealized Wind Component Profile Envelopes (95 to 115 Degrees Flight Azimuth) for Range Safety Analysis," October 16, 1962.

M-AERO-Y Memorandum for Record, "Directional Wind Component Frequency Envelopes for Titan II-Centaur Studies," June 6, 1963.

TABLE I

ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT-CROSS AND LEFT-CROSS) FREQUENCY DISTRIBUTIONS, FOR 5 to 6 KILOMETERS ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, CAPE KENNEDY, FLORIDA BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT

	Percentiles					
Azimuth*	30%	50%	75%	90%	95%	99%
			(meters/second)			
0	1	2	6	10	14	22
15	1	2	5	8	11	18
30	1	2	4	7	9	15
45	1	3	4	7	9	13
60	1	3	5	7	9	12
75	1	3	6	8	9	12
90	1	3	6	8	9	12
105	1	3	5	7	9	12
120	1	2	4	6	8	12
135	1	2	3	6	8	13
150	1	2	3	6	9	15
165	1	2	4	8	11	21
180	2	5	8	16	22	35
195	5	10	17	25	30	40
210	7	12	20	28	34	46
225	11	16	24	32	39	51
240	14	19	27	36	42	53
255	16	21	29	38	44	56
270	16	21	29	38	44	56
285	15	20	27	34	41	53
300	14	19	26	34	40	48
315	9	14	22	29	35	44
330	5	10	17	24	29	35
345	2	5	10	15	19	27
360	1	2	6	10	14	22

* Direction from which wind component is blowing. Referenced clockwise from true north.

TABLE II

ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT-CROSS, AND LEFT-CROSS) FREQUENCY DISTRIBUTIONS FOR 10 to 14 KILOMETERS ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, CAPE KENNEDY, FLORIDA BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT

Azimuth*	Percentiles 30%	50%	75%	90%	95%	99%
			(meters/second)			
0	2	6	14	24	31	40
15	4	7	12	19	25	32
30	4	8	12	17	21	28
45	4	8	13	18	22	30
60	4	8	14	20	24	30
75	4	7	12	18	21	26
90	0	6	13	19	22	26
105	2	4	10	17	21	26
120	2	3	7	12	16	26
135	0	1	5	10	15	27
150	0	1	4	10	15	30
165	0	1	4	13	22	45
180	1	5	12	23	33	54
195	12	20	30	40	50	66
210	17	25	36	48	58	76
225	26	33	47	57	66	86
240	34	42	56	67	73	93
255	39	46	57	68	75	97
270	41	47	56	67	74	95
285	37	44	53	65	73	89
300	31	38	49	60	69	79
315	23	31	40	51	59	68
330	15	21	31	42	50	60
345	6	11	21	33	41	50
360	2	6	14	24	31	40

* Direction from which wind component is blowing. Referenced clockwise from true north.

TABLE III

ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT-CROSS, AND LEFT-CROSS) FREQUENCY DISTRIBUTIONS FOR 18 to 20 KILOMETERS ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, CAPE KENNEDY, FLORIDA BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT

	Percentiles					
Azimuth*	30%	50%	75% (meters/second)	90%	95%	99%
0	1	2	5	8	10	13
15	3	4	6	8	9	13
30	5	6	8	10	11	14
45	8	9	11	13	14	16
60	10	11	12	14	16	18
75	10	11	13	15	17	19
90	10	12	14	16	17	19
105	10	12	12	15	17	18
120	7	9	10	12	14	16
135	5	7	9	11	12	14
150	2	4	6	8	9	13
165	1	2	3	6	8	14
180	1	2	5	9	11	18
195	2	4	9	14	18	24
210	5	7	12	17	22	31
225	7	11	16	22	26	36
240	8	13	18	25	30	40
255	10	14	20	27	32	47
270	10	14	20	27	32	42
285	10	14	19	24	29	40
300	11	15	19	23	27	34
315	9	12	17	20	23	27
330	5	8	13	16	19	22
345	2	4	8	10	13	16
360	1	2	5	8	10	13

* Direction from which wind component is blowing. Referenced clockwise from true north.

Based on Six Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, December 5, 1963

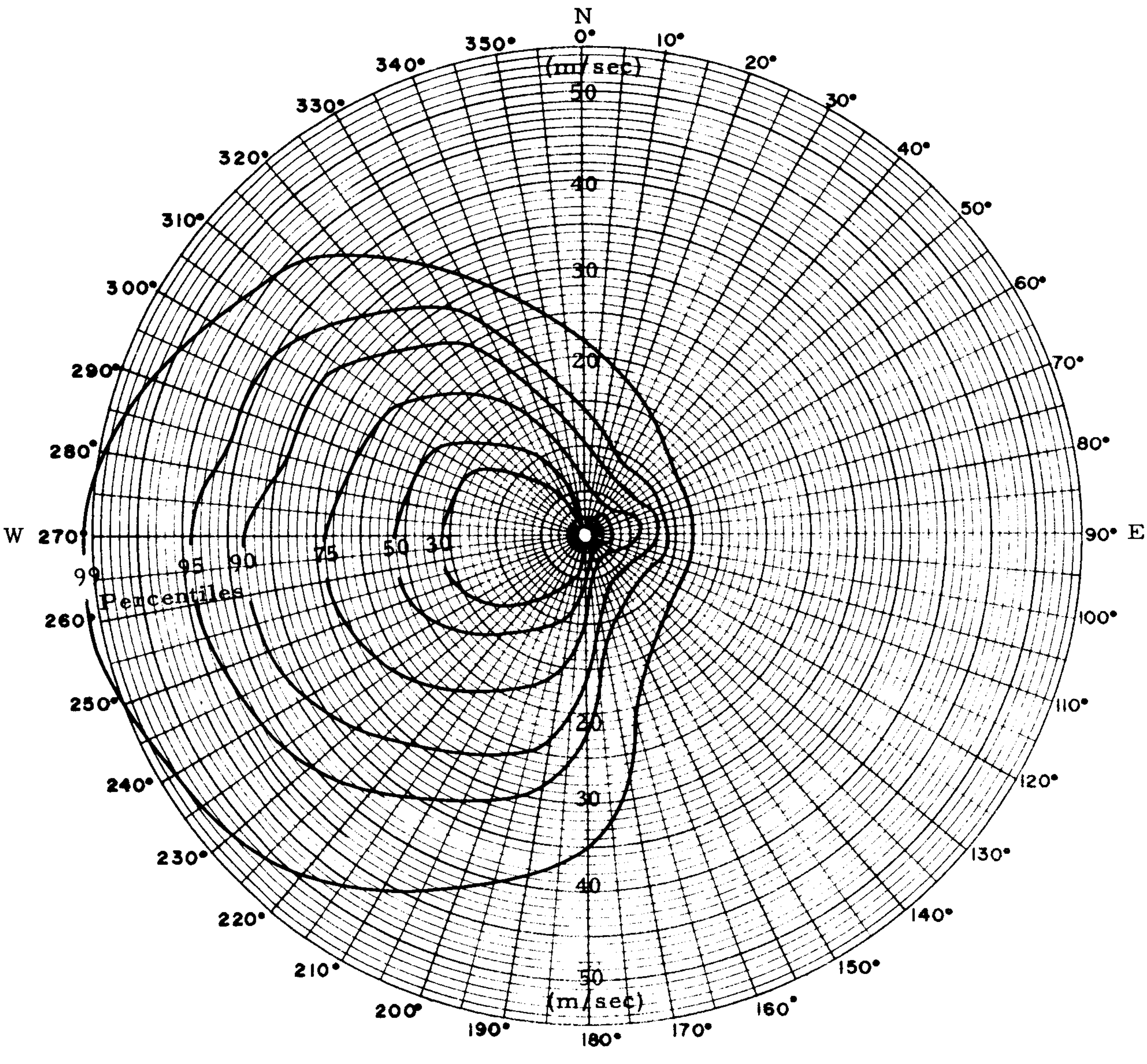

FIGURE 1. ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT CROSS, AND LEFT CROSS) FREQUENCY DISTRIBUTIONS, FOR 5 TO 6 KM ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, CAPE KENNEDY, FLORIDA. BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT.

Based on Six Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, December 5, 1963

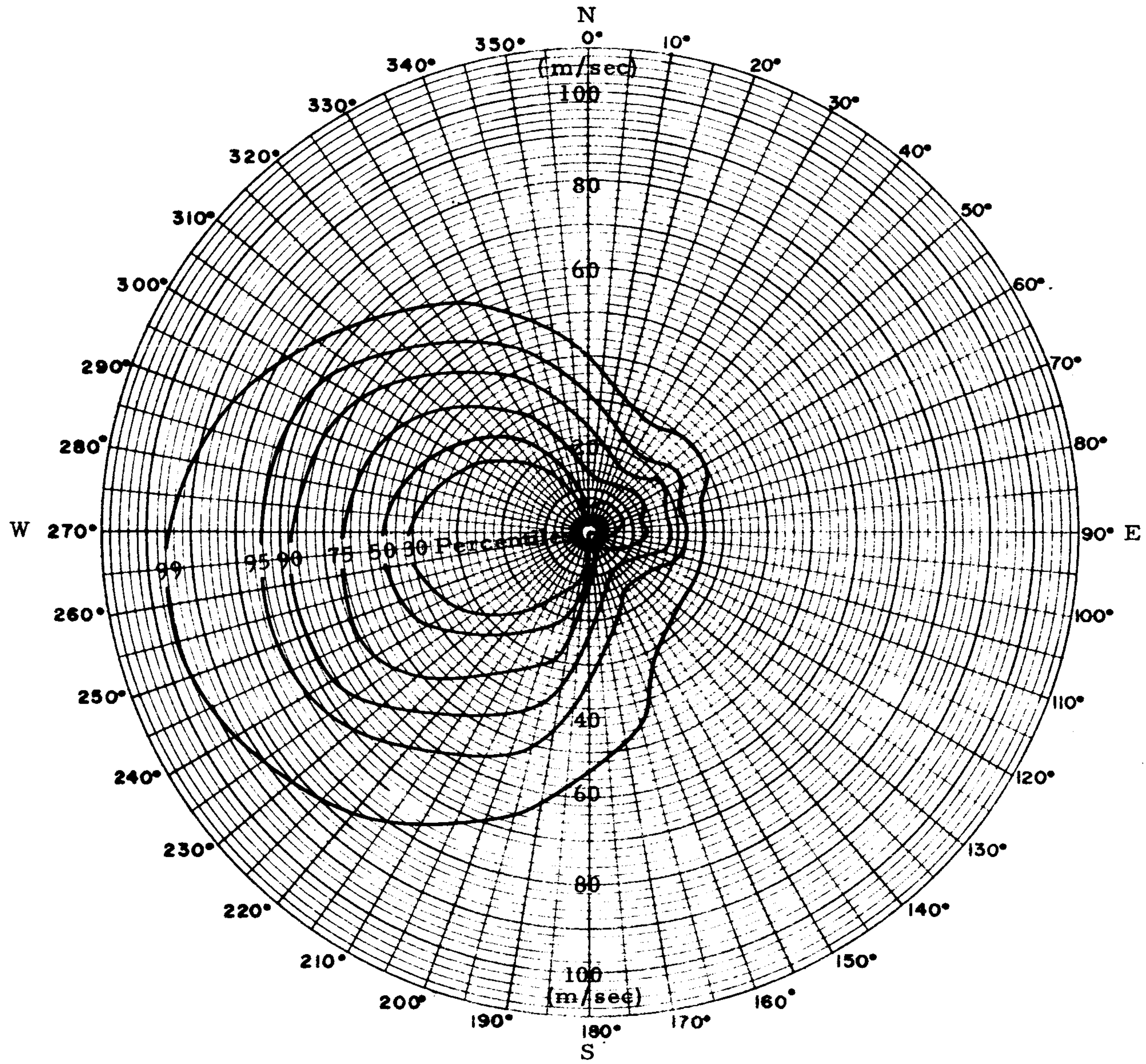

FIGURE 2. ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT CROSS, AND LEFT CROSS) FREQUENCY DISTRIBUTIONS, FOR 10 TO 14 KM ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, CAPE KENNEDY, FLORIDA. BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT.

Based on Six Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, December 5, 1963

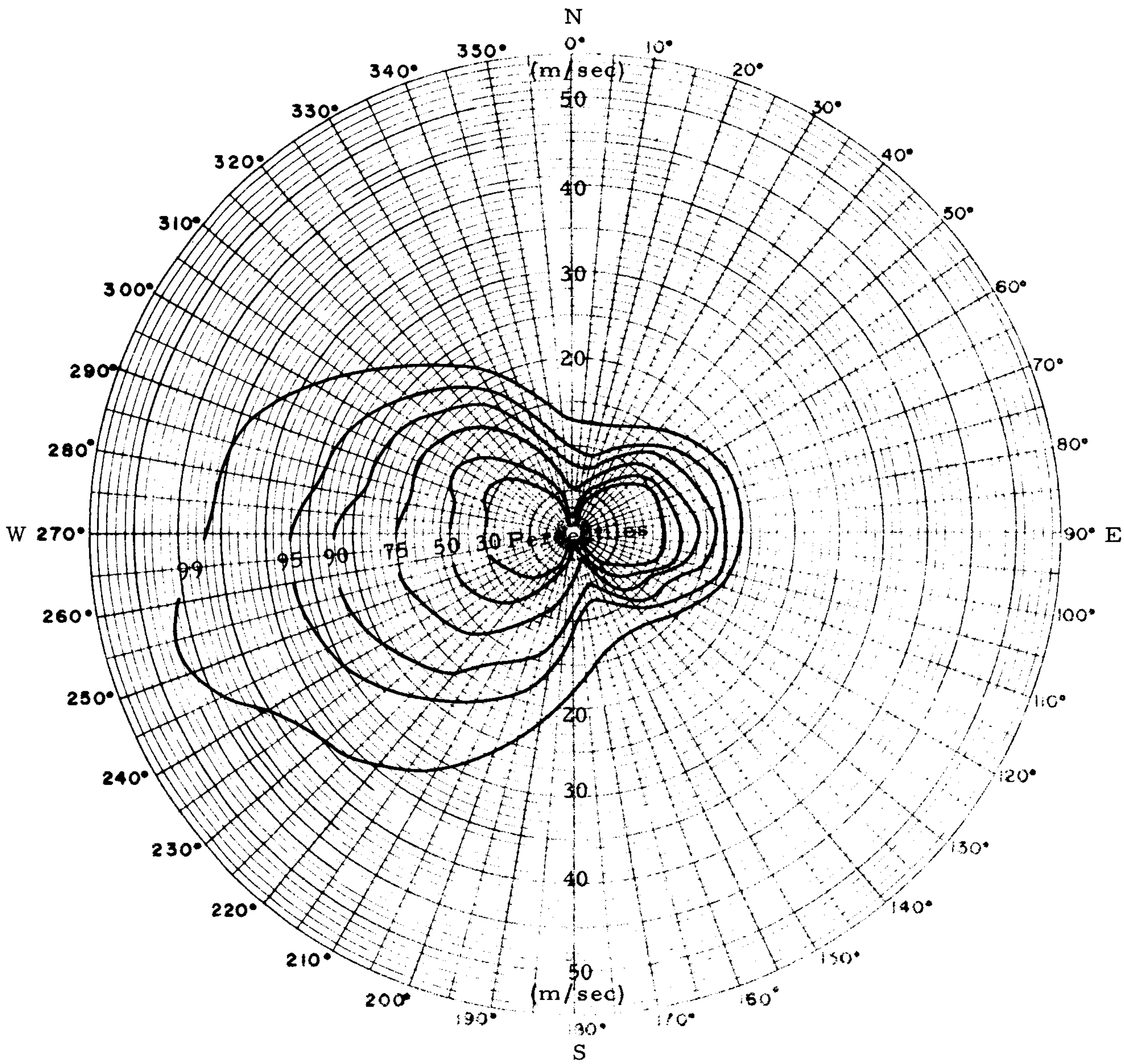

FIGURE 3. ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT CROSS, AND LEFT CROSS) FREQUENCY DISTRIBUTIONS, FOR 18 TO 20 KM ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, CAPE KENNEDY, FLORIDA. BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT.

Based on Six Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, December 5, 1963

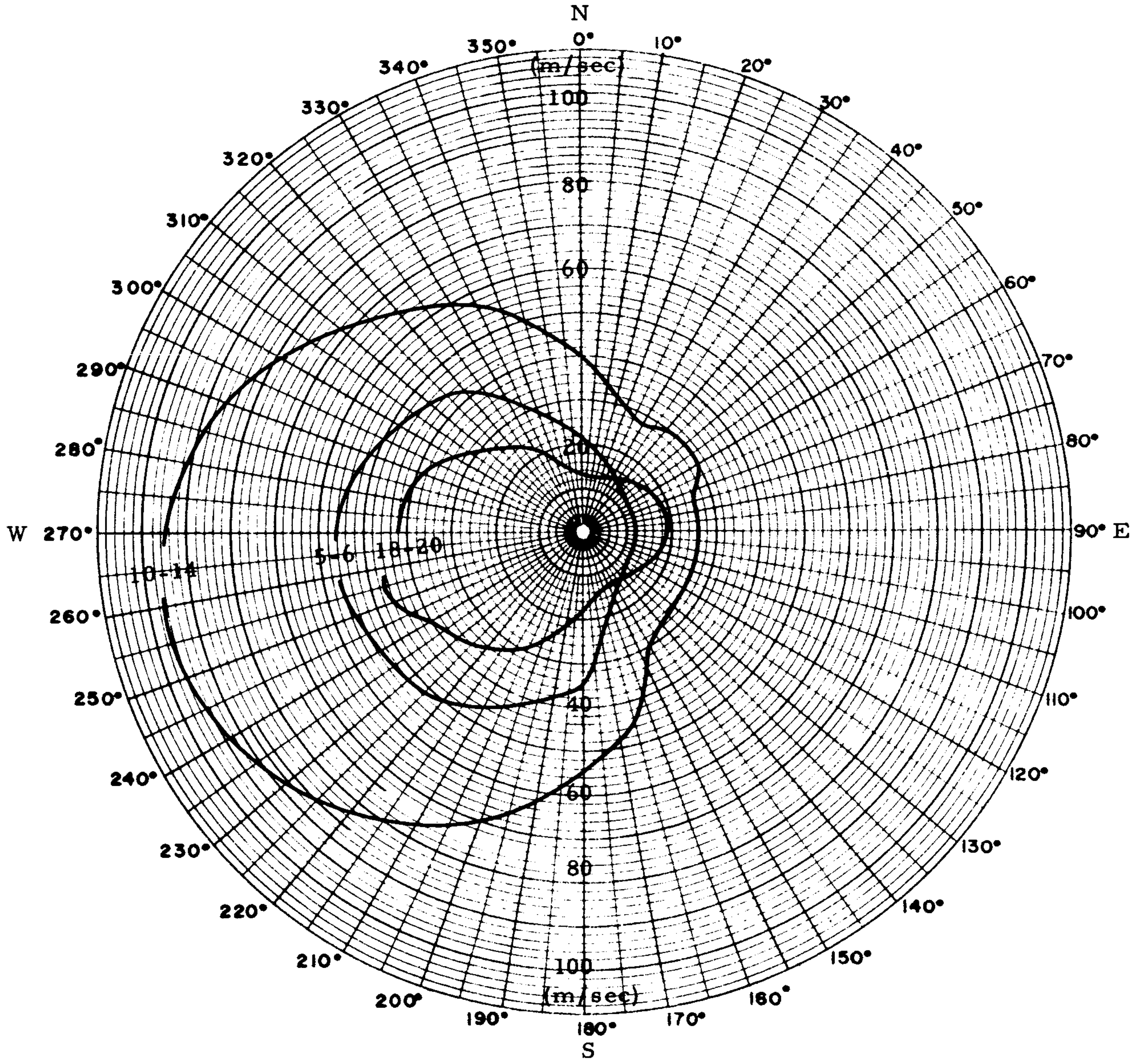

FIGURE 4. NINETY-NINE PERCENTILE ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENTS, AS A FUNCTION OF FLIGHT AZIMUTHS, CAPE KENNEDY, FLORIDA, BASED ON WINDIEST MONTHLY REFERENCE PERIOD.

Based on Six Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, December 5, 1963

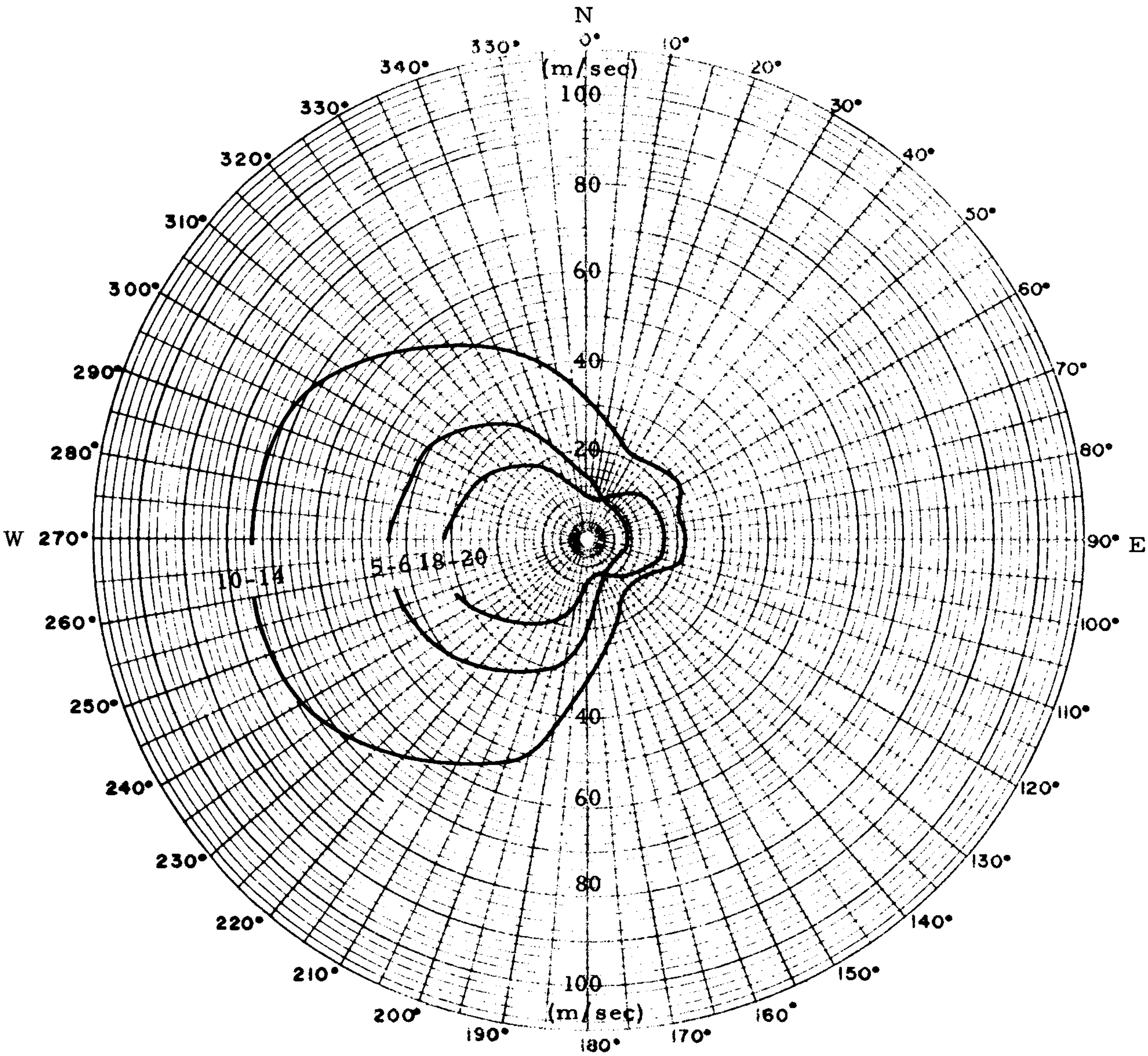

FIGURE 5. NINETY-FIVE PERCENTILE ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENTS, AS A FUNCTION OF FLIGHT AZIMUTHS, CAPE KENNEDY, FLORIDA. BASED ON WINDIEST MONTHLY REFERENCE PERIOD.

APPROVAL NASA TM X-53009

DIRECTIONAL WIND COMPONENT FREQUENCY ENVELOPES CAPE KENNEDY, FLORIDA, ATLANTIC MISSILE RANGE

By

Orvel E. Smith and Glenn E. Daniels

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Office. This report, in its entirety, has been determined to be unclassified.

Wm W. Vaughan

William W. Vaughan
Chief, Aero-Astrophysics Office

E. D. Geissler
Director, Aero-Astrodynamics Laboratory

DISTRIBUTION

DIR

DEP-T

R-ASTR
Mr. Hosenthien
Mr. Mink
Mr. Blackstone

R-P&VE-S
Mr. R. Hunt
Mr. J. Stevens
Mr. N. Showers

R-COMP-R
Mr. Paul Harness

R-DIR
Mr. Weidner

I-DIR

KN-TS
Dr. H. Knothe

KN-E
Dr. R. Bruns

MS-IP

MS-IPL (8)

R-AERO
Dr. Geissler
Mr. Jean
Mr. R. E. Cummings
Mr. McNair
Mr. de Fries
Mr. Dahm
Mr. Donehoo
Dr. Hoelker
Mr. Miner
Dr. Speer
Mr. Lindberg
Mr. L. Stone

R-AERO (continued)
Mr. Horn
Mr. Baker
Mr. Ryan
Mr. Rheinfurth
Mr. Golmon
Mr. Winch
Mr. Morrow
Mr. W. W. Vaughan (4)
Mr. J. R. Scoggins (2)
Mr. J. Kaufman
Mr. O. E. Smith (2)
Mr. J. W. Smith
Mr. G. E. Daniels (40)
Mr. J. D. Lifsey

EXTERNAL

Mr. John Estes
NASA-Lewis Research Center
System Analysis Br, Mail Stop 4-10
Agena Proj. Office
Cleveland, Ohio

Mr. H. B. Tolefson
NASA-Langley Research Center
Dynamic Loads Division
Langley Field, Virginia

Mr. Vernon L. Alley
NASA-Langley Research Center
Flight Vehicle Systems and Systems Div.
Langley Field, Virginia

Director
NASA-Manned Spacecraft Center
Houston, Texas

Mr. N. Sissenwine, CREW
Air Force Cambridge Research Laboratories
L. G. Hanscom Field
Bedford, Mass.

Scientific & Technical Information Facility
Attn: NASA Representative (S-AK/RKT) (25)
P. O. Box 5700
Bethesda, Md.